COST, PERFORMANCE, AND ESTHETIC IMPACTS OF AN EXPERIMENTAL FOREST ROAD IN MONTANA

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RESEARCH SUMMARY

A study on the Coram Experimental Forest in Montana was designed to assess the environmental impacts of harvesting and attendant road construction. The objective of the road portion of the study was to locate, design, and construct a road with reduced impacts (compared to standard practice) on the environment that would still serve the near-minimum needs of the projected traffic volumes, vehicle sizes, and logging equipment (skyline logging), and to evaluate the costs and impacts.

A single-lane (14-foot (4.27-m) finished surface with a 3-foot (0.91-m) dtich) road was constructed along the general contour, turnouts were fitted to the terrain and were not intervisible, and landings were not constructed. Other selected design criteria were also used to reduce impacts.

Skyline harvesting was accomplished from the single-lane road without undue difficulty, and it continues to serve traffic needs. Comparison of the road with adjacent, older forest roads incidates a major improvement in esthetic acceptability.

A comparison of hauling costs with a double-lane road, using traffic volumes appropriate for the area (10 VPH, 1/2 logging trucks), showed costs would be about \$2.35/M bd. ft. (\$0.59/m^3) higher for the single-lane road.

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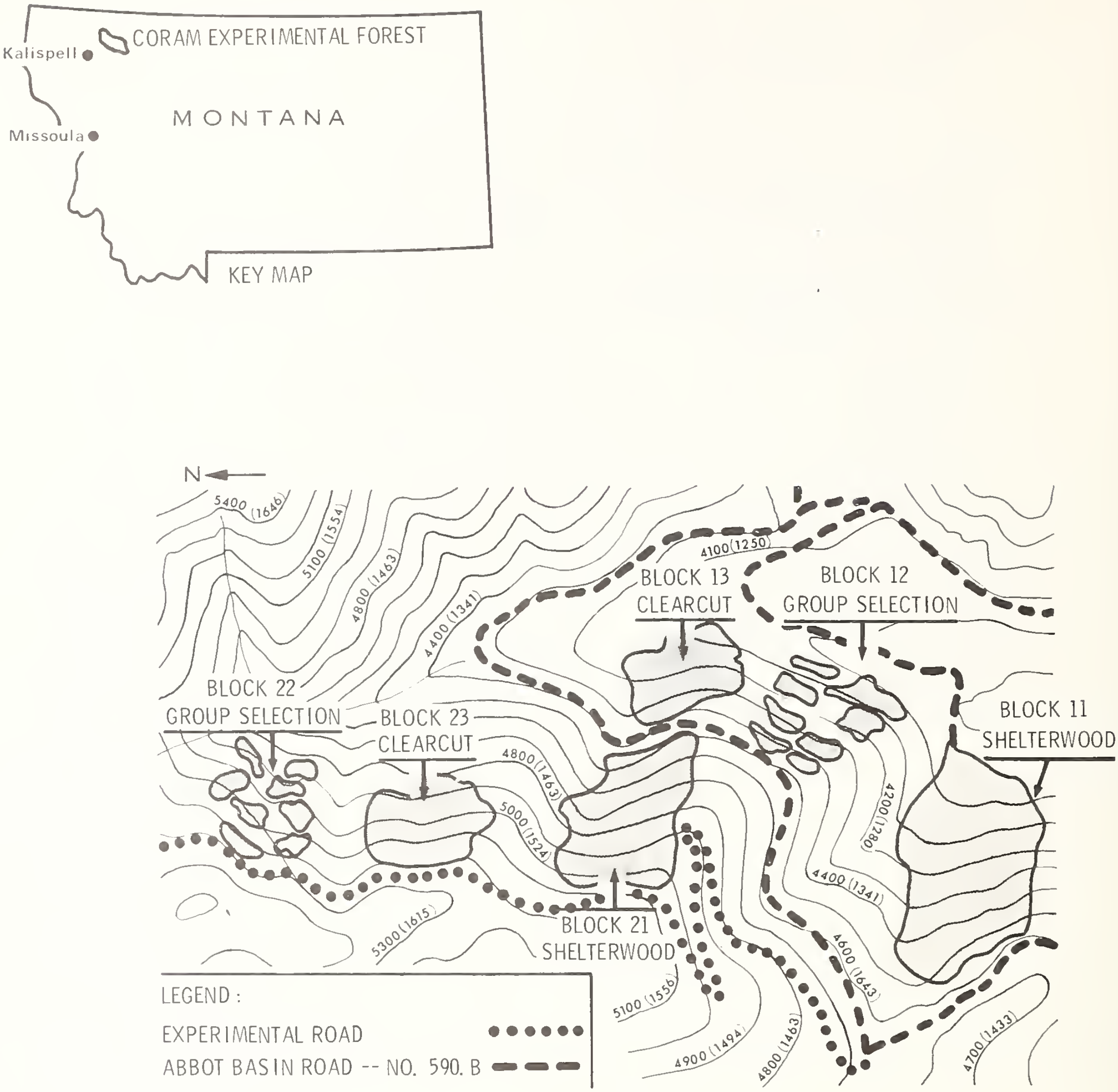

Figure 1.--Location and layout of experimental logging road on Coram Experimental Forest, Montana.

INTRODUCTION

Forest managers face a paradoxical challenge of utilizing forest resources (primarily timber) without damaging or destroying other assets of the forest. Also, with a decreasing land base available for timber growing, more intensive forestry must be practiced in the future. These facts, along the trend toward logging steeper terrain and more fragile soils, increase the potential damage from timber harvesting and road construction. Hence, minimizing the impacts of road construction while still providing for harvesting and traffic needs is essential for continued resource use.

In the past few years, more attention has been given to reducing road impacts, even though some of the trade-offs have not been very well defined. In the past, roads were designed primarily to serve the anticipated traffic needs of the access system. If traffic needs and user costs are the primary consideration, then often the environment suffers. Because so many forest roads must accommodate logging trucks, for safety and economic reasons roads of a higher standard (those incorporating extra width especially) have often been constructed at some expense to some, not well defined to date, environmental and social values.

Information is seriously lacking to evaluate trade-offs related to social, environmental, and economic values associated with different road standards. Because of the paucity of information on which to base decisions, many research projects are now underway or are planned. This paper reports one such study on the Coram Experimental Forest in Montana (fig. 1).

The broad objective of the road study was to locate, design, and construct a road with reduced impacts on the environment that would still serve the near-minimum needs of projected traffic volumes, vehicle sizes, and logging equipment, and to evaluate the costs and impacts. Some of the minimum road design criteria were set by the requirements of the logging and transport equipment. Small commercial running skyline systems were specified to reduce road width requirements as much as possible. This report evaluates road design, construction, and cost and compares costs to those of alternative designs. Also, observations of initial performance of the road and its esthetic acceptability are presented.

ROAD LOCATION AND DESIGN

General Design Procedures

Until the past few years, the environmental and social impacts of road construction were given little or no consideration. Road standards were concerned primarily with the geometric and structural features that would provide safe and economical transportation. These standards specified some or all of the following:

--width of road x-section
--width of clearing
--grade
--alinement
--water control specifications (drainage)
--consolidation (bearing strength)
--surfacing.

The principal differences among standards are grade, width, alinement, and surfacing. A so-called low-standard road is often thought to be associated with high environmental impact and a high-standard road with low environmental impact. (Often the results can be opposite to these assumptions.) A road standard, as the term has generally been used, should not be used alone as an indicator of impact--more information about a road is needed to judge impact.

Recognizing the importance of topographical location, proximity to streams, and fragile soils, the environmental and esthetic impacts of roads can usually be minimized by reducing road and clearing widths. Reducing widths accomplishes the following:

--Reduces the area covered by the road x-section which in turn:

--reduces the amount of cut-and-fill slope exposed to view,
--intercepts less ground and surface water flow, thereby reducing potential hydrologic impact, and
--reduces the potential for erosion.

Other design features that reduce impacts are:

--fitting the alinement to the topography to avoid large cuts and fills
--providing adequate drainage for surface and subsurface flow
--stabilizing subgrades and surfaces
--stabilizing cut-and-fill slopes by vegetative and mechanical methods.

The guiding criterion for the experimental road was to reduce impacts while still providing for the basic requirements of the traffic and logging equipment; therefore, width became the most important design feature to reduce exposed area and resulting impacts.

Experimental Road Design

Objectives and Guidelines

The road was constructed to provide access for an experimental logging study of the productivity of skyline logging under different silvicultural and utilization prescriptions. The principal guidelines and constraints were:

--to reduce physical and visual impacts on the site and
--provide access to the harvesting units for all traffic and skyline logging equipment.

Within these guidelines, the major objectives of the study were to:

--develop design criteria to reduce physical and visual impacts and
--assess the environmental impacts and economic performance of the road.

Location and Design

The areas to be harvested and the new road constructed to provide access are shown in figure 1. Three cutting blocks 11, 12, and 13 were accessible from an existing road (Flathead NF road 590-B). The experimental road, an extension of road 590-B, was built to provide access to the other three blocks 21, 22, and 23.

Planning and design for this road proceeded somewhat differently from a normal forest road because of the objectives. However, route reconnaissance and verification proceeded in a normal manner using access needs, available photography, and soils and geologic information. Whenever a skyline logging system is used and access starts from below the units (fig. 1), it is often advantageous to switch back on the terrain to gain the elevation needed for the skyline system. The locations found for the second and third switchbacks, shown in figure 1 and appendix figures 17 and 18, fixed the ruling grade for the primary climbing sections of the road from approximately station 5+00 to 45+00.

After the route was selected, the design phases proceeded differently than for a system road. Because the primary objective was to reduce impacts, especially esthetic impacts, road width was set at the width that would accommodate the tracks of the proposed yarding equipment (12.5 ft (3.81-m)), with a minimum extra width for safety, and a ditch was added for drainage--14-foot (4.27-m) finished surface, with a 3-foot (0.91-m) ditch (app. fig. 19). Normally, a log-hauling cost analysis would be made at this point to assist in determining road width, curve radius, sight distances, and turnout spacing. Instead, the 14-foot (4.27-m) surface was used, and turnouts were placed where the terrain was favorable and are not intervisible as normally desired. As mentioned earlier, landings were not specifically designed, although it was apparent that turnouts and areas where curves were widened could be planned for use as landings.

The following features were specified for the final design.

1. Right-of-way slash was disposed of on the first 59 stations by chipping and scattering. The balance of the slash to station 105+19 was disposed of by burning.

Traditionally, right-of-way slash has been burned. Burning, properly done, not only disposes of the slash, it also immediately returns nutrients to the soil. However, because the area burned is later incorporated in the road, the nutrient return value is questionable. If the job is not done properly, quantities of unburned material usually end up in the road fill. Either way, smoke from burning is objectionable.

An alternative method used for many years for powerline right-of-ways, especially in gentle terrain, is to chip and scatter the slash. To compare costs and results, this treatment was incorporated.

2. Station 26+00 to 58+00--trees were cut selectively on both cut-and-fill sides. Removal on cut side as near as possible to cut without danger of slope failure; fill side a minimum of 8 feet (2.44-m) from road shoulder, or the branches trimmed to not interfere with traffic.

Conventional clearing widths have traditionally extended 5 feet (1.52-m) back from the cut slope and minimum of the toe of the fill slope, both depending on soil and timber types and, in some cases, climatic factors. In order to reduce clearing widths to minimize esthetic impacts, the clearing widths were modified as shown.

3. Station 49+00 to 58+00--subsurface conditions allowed for the use of 1/10:1 cut backslopes.

A seismic traverse was run over the entire route to assist in the design of the backslopes. The bedrock in this section was soft enough to rip, (seismic velocity 4,000 ft/sec (1,219 m/sec)), but competent enough to stand on 1/10:1 backslopes. The objective was to reduce the amount of area disturbed by the road prism and the subsequent clearing necessary. Because the exposed rock sections (3/4:1 slopes) on the old road below had not revegetated in 20 years, opening up flatter slopes would appear merely to expose more raw slope to weathering. The steep slopes produce air-slacked material, but so do the flatter slopes.

4. Turnouts were not intervisible.

Turnouts were used when the terrain was favorable, thus keeping road widths down, to reduce impacts. Modern logging trucks are equipped with two-way radios that can be used to regulate traffic. This helps compensate for reduced spacing and reduces potential traffic dangers. (This road was closed to public traffic during the study.)

5. Stepped backslopes were used from approximately station 79+09 to 83+53 and were planted to different varieties of shrubs or grass.

Seismic velocities here (station 79+09 to 83+53) showed that the bedrock was competent to experiment with the stepped backslopes shown in appendix figure 19. When good fill or surface material is needed in a road and, for reasons of overall economy it can be obtained from a cut slope in a favorable location, then some treatment to dampen the appearance of the cut should be utilized. Shrubs were planted in this section to evaluate this treatment.

6. Other selected 3/4:1 backslopes were planted to shrubs or grass.

Revegetation success on road cut slopes steeper than 1:1 has not been good in most areas of the United States. The reasons are usually instability from air slacking or sloughing, and sometimes lack of moisture because of exposure (aspect). Grass seeding was carefully done with and without a mulch and shrubs were planted to test the cost and effectiveness on some selected slopes steeper than 1:1.

7. Selected fill sections were straw mulched and rolled with an Angeles NF-designed, sheep's foot-type roller to impregnate the straw and stabilize the surface of the fill slope.

One of the most effective ways to stabilize steep, granular fill slopes is by impregnating straw with a special roller. The straw does not blow or wash off the slope, and the roller compacts the top 6 to 8 inches (15-20 cm) of loose soil on the slope.

8. Neoprene downspouts were used because of better stability on the fill slopes and ability to dissipate part of the energy at the outflow.

Although neoprene downspouts have been used quite often in the past few years, there is still a need for more testing, especially for functioning in different situations and for more information about the life of these structures. Because they do not require anchoring on the slope or connecting bands, they are not likely to be displaced.

Design criteria produced a road shown in the following descriptions and table 1.

--Length - 2.046 miles (3.292 km).
--Width - 14 feet (4.27 m) with 3-foot (0.91 m) ditch--turnouts were combined with probable logging set locations; standard curve widening.
--Maximum grade - 9.41 percent; average grade - 6.72 percent.
--Minimum curve radius - 75 feet (22.9 m).
--Surfacing - none.
--Standard clearing width - 5 feet (1.52 m) from cut slopes and toe of fill.
--Clearing from station 26+00 to 58+00 - trees cut selectively on both cut-and-fill sides--removed on cut side as near as possible without danger of slope failure; fill side a minimum of 8 feet (2.44 m) from road shoulder, or the branches trimmed to not interfere with traffic.
--Culverts - 18-inch (0.457-m) C.M.P. minimum size.
--Downspouts - flexible neoprene.
--Compaction - with grading equipment.

Table 1.--*Grade, distance, and alinement--experimental section Abbot Basin Road 590-B*

Section		Station	Grade	Distance		No. curves	Curve radius
		100 ft	*%*	*Mi*	*(km)*		*Degrees*
I	1	0-2+00	3.85	0.038	(.061)	0	
	2	2+00-5+00	6.60	.057	.092	2	108, 108
	3	5+00-7+00	4.65	.038	.061	0	
	4	7+00-16+60	8.82	.182	.293	2	716, 573
	5	16+60-21+00	8.64	.083	.134	2	143, 143
	6	21+00-25+00	6.84	.076	.122	0	
	7	[1]22+14-26+50	9.12	.083	.134	2	286, 358
	8	26+50-30+50	5.25	.076	.122	2	88, 88
	9	30+50-36+00	8.22	.104	.167	3	119, 358, 358
	10	36+00-42+55	7.53	.124	.200	4	409, 204, 179, 358
	11	42+55-48+00	3.85	.103	.166	2	75, 75
	12	48+00-56+00	7.06	.152	.245	3	358, 358, 239
	13	56+00-59+40	9.41	.064	.103	1	143
II	14	59+40-65+50	6.19	.112	.196	2	204, 179
	15	65+50-70+50	4.45	.095	.153	1	500
	16	70+50-74+50	7.62	.076	.122	2	477, 140
	17	74+50-85+00	5.63	.199	.320	3	477, 573, 179
	18	85+00-91+00	8.39	.114	.183	3	358, 143, 143
	19	91+50-94+65	6.58	.069	.111	1	204
	20	94+65-99+00	1.38	.082	.132	1	286

[1]Equation:

For analysis purposes (used later), the road was divided into two sections--major climbing and switchback 0+00-59+40 and 59+40-99+00.

	Ave. grade	Ave. curve radius	No. curves/mile (/km)	
Section I	7.26%	229	19.4	(12.1)
Section II	5.90%	297	17.4	(10.8)

ALTERNATIVE DESIGNS, CONSTRUCTION, AND COSTS

Alternate Designs and Construction Cost

To evaluate the probable effects of alternative designs, the study road P-Line location is retained and adjustments for different standards made from the P-Line. (The P-Line, or route location, is of prime importance no matter what width or other parameter adjustments are made to the final design. Often it is impossible for design changes and innovations to compensate for inadequate route selection.) Because of the relatively small central angles for most curves on the design road, except the switchbacks, and because of the minimum curve radius of 75 feet (22.9 m), the primary adjustments made for two simulated road standards (an SN-16 (4.88) and a DN-24 (7.32)) were in road and clearing widths. The designations for road standards in the Forest Service are being revised. In the old system, SN-16 (4.88) designates a single-lane, normal 16-foot-wide (4.88 m) road. In the new nomenclature, the numbers following the letter designations represent design speed. For example, S-15 (24.1) designates a single-lane, road designed for a speed of 15 miles per hour (24.1 km/h). The latter designation is more descriptive of the trafficability, but doesn't give specific information about width. However, often because of curve widening, width added for settling and slough, and turnouts, width of a single-lane road varies so much that very few sections end up design-template width, anyway. Both designations for standard will be shown, with the design speed designation in parentheses.

For comparison, the side-by-side quantities and cost will be shown for each case or standard below:

I. SN-14 (4.27) (S-15 (24.1)) - 3-foot (0.91-m) ditch (the experimental road).

II. SN-14 (4.27) (S-15 (24.1)) - 3-foot (0.91-m) ditch without backslope or clearing modifications; that is, 3/4:1 backslopes throughout, standard clearing widths.

III. SN-16 (4.88) (S-17 (27.4))[1/] - 3-foot (0.91-m) ditch with the same backslope and clearing modifications as the experimental road.

IV. DN-24 (7.32) (D-24 (38.6)) - 4-foot (1.22-m) ditch with the same backslope and clearing modifications as the experimental road.

The design quantities were computed using the computer program of the Northern Region, Missoula, Montana. Table 2 shows the construction items and cost for each of the above standards.

1/ Normally a road would not be designed for a speed of 17-mi/h (27.4-km/h)--in this case, the 16-foot-wide (4.88-m) road with turnouts provides a facility for 17-mi/h (27.4-km/h) traffic.

Table 2.--*Construction items, unit cost, total cost, and cost per kilometer (mile) of alternative road standards (Dollars)*

Construction item	Unit of measure	Unit cost	I Units	I Cost	II Units	II Cost	III Units	III Cost	IV Units	IV Cost
Clearing and grubbing (chipping)	hectare (acre)	4,568.00 (1,850.00)	3.24 (8.00)	14,800	3.44 (8.50)	15,725	3.50 (8.65)	16,002	4.28 (10.58)	19,573
Clearing and grubbing (burning)	hectare (acre)	3,951.00 (1,600.00)	2.54 (6.27)	10,032	2.57 (6.34)	10,144	2.74 (6.77)	10,832	3.50 (8.63)	13,803
Unclassified excavation (Std. I, II, and III)	$meters^3$ ($yards^3$)	1.63 (1.25)	34,773 (45,483)	56,854	36,664 (47,957)	59,946	37,948 (49,636)	62,045		
Std. IV		1.25 (0.96)							59,086 (77,284)	74,193
Slope Rounding	(linear) meters (feet)	0.11 (0.35)	744 (2,440)	854	744 (2,440)	854	744 (2,440)	854	744 (2,440)	854
Overhaul	m^3 km (yd^3 mi)	2.63 (1.25)	82.3 (173.3)	217	159.8 (336.4)	420	148.9 (313.4)	392	205.5 (432.6)	530
Corrugated metal pipe--4.57 m (18 in) dia.	(linear) meters (feet)	26.30 (8.00)	152 (500)	4,000	152 (500)	4,000	177 (580)	4,640	211 (691)	5,528
Total cost	$			86,757		91,089		94,765		114,481
Cost per km (mile) for 3.29 km (2.046 mi)	$/km			26,370 (42,403)		27,686 (44,520)		28,804 (46,317)		34,797 (55,954)

It is readily apparent from table 2 that using 1/10:1 backslopes, where subsurface conditions were favorable, and reducing clearing widths, saved cost ($4,333) and reduced impact with no adverse effects on logging or hauling cost.

The cost of a conventional road can be estimated from table 2 by using standard clearing and grubbing cost ($1,600/acre ($3,951/ha)) for these quantities for road standard II. The estimated cost for a conventional road then is $88,965 vs $86,756 for the experimental road.

User Cost

The differences in construction cost show the additional capital investment required for higher standard roads. One must also compare effects of standards on user cost. For most forest roads, timber hauling cost is the major user cost.

As normal planning procedure, these costs are used to compare the potential benefits with the impacts they create to assist in determining road standards. A volume of traffic of 10 vehicles per hour is assumed for the computation of minutes per round trip mile (kilometer) in tables 3, 4, and 5. This was done to make the comparison for traffic volumes more typical of a system road in this area. The Logging Road Handbook, Byrne and others (1960) was used for the computation.

Tables 3, 4, and 5 show that when a road is laid lightly on the land (contoured), the alinement will usually control the speed, when ruling grades are less than 6 to 7 percent. This means that any significant improvement in speed (reducing vehicle user cost) must be gained by increasing width, as was done in this case.

Under the assumptions used for table 6, 12,936 M bd. ft. (51,223 m^3) of timber would be carried over the road annually. Although 10 VPH is relatively light traffic when a substantial part of the traffic is logging trucks, 50 percent in this case, a rather large volume of timber could be transported each year. As traffic increases, especially logging traffic, users tend to favor higher standards because of lower costs (Gardner 1971).

Table 3.--*Minutes per round trip mile (km) - SN-14 (4.27)(S-15 (24.1))*

Road section1/	Grade		Alinement	
	Loaded	Empty	Loaded	Empty
I	2.55 (1.58)	2.25 (1.40)	4.00 (2.49)	3.90 (2.42)
II	2.20 (1.37)	1.90 (1.18)	3.50 (2.18)	3.50 (2.18)

	Time gov. by empty2/	Total time RTM (RTKm)	Distance RT	Time/section
I	4.13 (2.57)	8.13 (5.05)	2.26 (1.40)	18.37 (11.42)
II	3.80 (2.36)	7.30 (4.54)	11.49 (0.93)	10.83 (6.73)

1/ Road sections are used to facilitate the hauling analysis as shown in table 1.

2/ Increase dependent on spacing of turnouts.

Total time RTM = 18.37 + 10.83 = 29.20 min
Total time RTKm = (11.42) + (6.73) = (18.15) min
Weighted average for both sections = 7.79 min/RTM (4.84 min/RTKm) (15.4 mi/h (24.8 km/h))

Table 4.--*Minutes per round trip mile (km)--SN-16 (4.88) (S-17 (27.4))*

Road section	Grade		Alinement	
	Loaded	Empty	Loaded	Empty
I	2.55 (1.58)	2.25 (1.40)	3.70 (2.30)	3.50 (2.18)
II	2.20 (1.37)	1.90 (1.18)	3.40 (2.11)	3.20 (1.99)

	Governing time	Total time RTM (RTKm)	Distance RT	Time/section
I	3.71 (2.31)	7.41 (4.61)	2.26 (1.40)	16.75 (10.41)
II	3.47 (2.16)	6.87 (4.27)	1.49 (0.93)	10.24 (6.36)

NOTE: Total time RTM = 16.75 + 10.24 = 26.99 min
Total time RTKm = (10.41) + (6.36 = (16.77) min
Weighted average for both sections = 7.20 min/RTM (4.52 min/RTKm) (16.7 mi/h (26.9 km/h))

Table 5.--*Minutes per round trip mile (km) - DN-24 (7.32) (D-24 (38.6))*

Road section	Grade		Alinement	
	Loaded	Empty	Loaded	Empty
I	2.55 (1.58)	2.25 (1.40)	2.60 (1.62)	2.60 (1.62)
II	2.20 (1.37)	1.90 (1.18)	2.30 (1.43)	2.30 (1.43)

	Governing time	Total time RTM (RTKm)	Distance RT	Time/section
I	2.60 (1.62)	5.20 (3.23)	2.26 (1.40)	11.75 (7.30)
II	2.30 (1.43)	4.60 (2.86)	1.49 (0.93)	6.85 (4.26)

Note: Total time RTM = 11.75 + 6.85 = 18.60 min
Total time RTKm = (7.30) + (4.26) = (11.56) min
Weighted average for both sections = 4.96 min/RTM (3.08 min/RTKm) (24.1 mi/h (38.8 km/h))

For the cost comparisons in tables 6 and 7, the following assumptions were made:

Table 6

--10 vehicles per hour (VPH)--with half of the traffic logging trucks and half administrative and other traffic.
--cost of operating logging trucks, including the drivers' wages--0.25/min.
--cost of operating other vehicles--0.04/min.
--8-hour hauling day, 140 days per year use.
--20-year road life.
--6 percent interest.
--6.0 M bd. ft. (23.8 m^3) loads for logging trucks.

Table 7

--5 VPH--half logging, half other.
--all other assumptions same as table 6, except
--average load of logging and residue trucks used from Coram experimental logging study--3.84 M bd. ft. (15.2 m^3).

Table 6.--*Cost summary comparison (10 VPH--1/2 logging trucks, 1/2 other traffic)*

Road standard	Annual amortized diff. in cost[1]	Annual diff. hauling cost	Annual diff. other traffic	Net diff.
	Dollars			
I	0			
III	+ 1,842.99	- 6,209.28	- 862.40	- 5,228.64
IV	+11,790.22	-30,529.96	-4,743.20	-23,482.94

[1]Capital recovery--6%, 20-year life.

Table 7.--*Cost summary comparison (5 VPH--1/2 logging trucks, 1/2 other traffic)*

Road standard	Annual amortized diff. in cost	Annual diff. hauling cost	Annual diff. other traffic	Net diff.
	Dollars			
I	0			
III	+ 1,842.99	- 3,187.65	- 431.20	-1,775.86
IV	+11,790.22	-15,287.59	-2,371.60	-5,868.97

The data in table 7 more nearly approximate the traffic volume for the experimental sale (presently a dead end road), although the traffic was more intermittent and did not extend for a full 140 days during the year of the logging (1973).

Table 7 also indicates that this volume of traffic is near the break even point for road standards (primarily width in this case) related to hauling cost. For this particular road, just wide enough for the logging equipment, any environmental values obtained would cause little economic sacrifice. (For the Coram experimental sale, only about 1 1/2 million board feet (5,535 m^3) were harvested).

The preceding discussion and comparisons would be useful for deciding road standards. To complete an analysis of road standards, the effect of the road standard on harvesting cost as well as hauling cost would be necessary. However, the effects on harvesting cost could not be made for this study where only one standard was built.

ROAD PERFORMANCE TO DATE

Structural Features

Road inspections of April and June of 1974 and observations throughout the summer and fall of 1974 showed no structural failures of any kind. Some minor sloughing and settling had occurred.

1/10:1 backslopes.--Two photos taken from approximately station 54+00, after the first winter and after final grading, tell the story. Figure 2 shows two or three sections where 1/2 to 1 cubic yard (0.13-0.26 m^3) of rock sloughed off the cut bank. Figure 3 shows the same section of road after final grading and how it appeared the balance of the year. Only minor sloughing is likely in the future.

3/4:1 backslopes.--Two areas of 3/4:1 backslopes showed some sloughing or slumping after the first winter, but are now relatively stable and no major failures are anticipated. Figure 4 shows minor slumping at station 37+20 on a relatively long slope in the deepest soil mantle found on the entire road. Some minor sloughing or slumping could be expected on 3/4:1 backslopes in this material.

Figure 2.--Near station 54+00--view of 1/10:1 backslopes before final grading.

Figure 3.--Near station 54+00--view 1/10:1 backslopes after final grading.

Figure 4.--Slumping cut slope near station 37+20.

Figure 5.--Minor settlement in rock fracture at station 64+34.

A minor U-shaped settlement occurred in the cut bank at station 64+34 (fig. 5) because of rock fracturing.

In figure 6, several yards of rock slabbed off the cut bank at station 76+20 because of dip and fracture in the bedrock. No further sloughing of any extent is expected here.

Stepped or serrated backslopes.--An experimental section of approximately 450 feet (137 m) of backslope was stepped to test growth of grass and shrubs and to evaluate esthetics and stability. This area has relatively high precipitation and a favorable aspect. Revegetation success was generally good. Figure 7 shows a completed section of serrated backslope. The dip and strike of the rock formations made stepping difficult and resulted in the steps being not quite as wide as planned. The steps have been planted, and it is believed that most of the sloughing expected has taken place. Sloughing eventually leaves less pronounced steps, but provides a seedbed and more moisture to the plants.

Fill slopes.--Fills were designed on either a 1 1/2:1 or 1 1/4:1 slope, depending on the material. Many sections contained enough rock to support 1 1/4:1 slopes. Fill slopes were compacted by the earth moving equipment. Figure 8 shows a typical fill at station 87+75. The material in the area of station 93+00 produced the only section where the fill slope was slightly undulating, shown in figure 9.

Figure 6.--Rock slab spalling due to dip and fracture at station 76+20.

Figure 7.--Stepped backslopes in rock cut near station 82+50.

Figure 8.--Typical side-cast fill on 1 1/2:1 slope at station 87+75.

Figure 9.--Fill containing some fine colloidal material that produced a slightly uneven but stable slope at station 93+00.

Drainage

Drainage is provided by a 3-foot (0.91-m) ditch, corrugated metal pipe, and neoprene downspouts. Only three culverts experienced any flow during the first year. However, seasoning of the ditch sections will produce more flow in the future.

Minor seepage was recorded in April from four cut bank sections at stations 12+40, 21+75, 41+00, and 55+00. The seepage at the first two locations continued throughout the year, but no damage resulted from the seepage. A typical area of seepage is station 41+00, shown in figure 10.

Neoprene downspouts were used because of their greater stability on fill slopes and effectiveness in dissipating part of the energy under conditions of flow. The installation at station 57+50 is shown in figure 11.

Porous soil over the fractured limestone basin minimized the need for water control.

Figure 10.--Typical minor seepage at station 41+00.

Figure 11.--Neoprene downspout laid on top of fill at station 57+50.

Clearing

Slash from the road right-of-way was disposed of on the first 59 stations by chipping and scattering. Because of this requirement, the contractor removed and sold much more small material than he would have on a pile-and-burn operation. This resulted in very small volumes of material being chipped and scattered. The author couldn't find a concentration of chips visible enough to photograph! Only the tops and limbs, in most cases, were chipped in a small Fitchburg right-of-way chipper.

The difference in overall appearance between the standard and reduced clearing widths can be seen in figures 12 and 13. As previously discussed, reduced clearing widths generally reduce esthetic impacts.

Figure 12.--Road section, conventional clearing.

Figure 13.--Road section with vertical cut and reduced clearing width.

Erosion

Runoff and erosion were not anticipated to cause significant problems because of the leaky, fractured limestone basin and the road material. There was no evidence of overland flow on the location before the road was constructed, and very little subsurface flow has been intercepted by the road prism. Obviously, the percolation rate is high and the phreatic gradient steep.

The first year after construction, ditch flow was small and carried little or no sediment. No evidence of overland flow of sediment was found and little or no sediment is expected. The entire section of road is separated from any live stream. Hence, if in the future any sediment flow does develop, it would not reach a live stream.

Revegetation

Because the revegetation experiments will be reported in detail in another paper, only the generalities will be discussed here. The primary objectives of revegetation were to help stabilize the slopes and reduce visual impact. The relative importance of these objectives for any road varies with the location of the road. Location affects stability and visual considerations. For example, in some cases, revegetation could be entirely for esthetic reasons.

The shrubs and grass used for revegetation were listed in appendix tables 8 and 9, along with the first-year survival on the shrubs. Obviously, the effect of these plantings on the appearance of the road cannot be evaluated until the shrubs have had some time to develop. Initial survival is very good and, since this is the most critical time for survival, good overall results are expected.

Fill slopes that are difficult to revegetate have generally been most successfully treated by applying a mulch held in place by netting or impregnation. The sheep's foot-type roller, designed by the Angeles National Forest (fig. 14), has been proven effective in compacting the top 6 to 8 inches (15-20 cm) of soil, while at the same time impregnating straw mulch well into the soil. The roller was used on several fill sections; results will be reported when data have been analyzed. (The experimental seeding and planting were done by research personnel and were not a part of the road contract.)

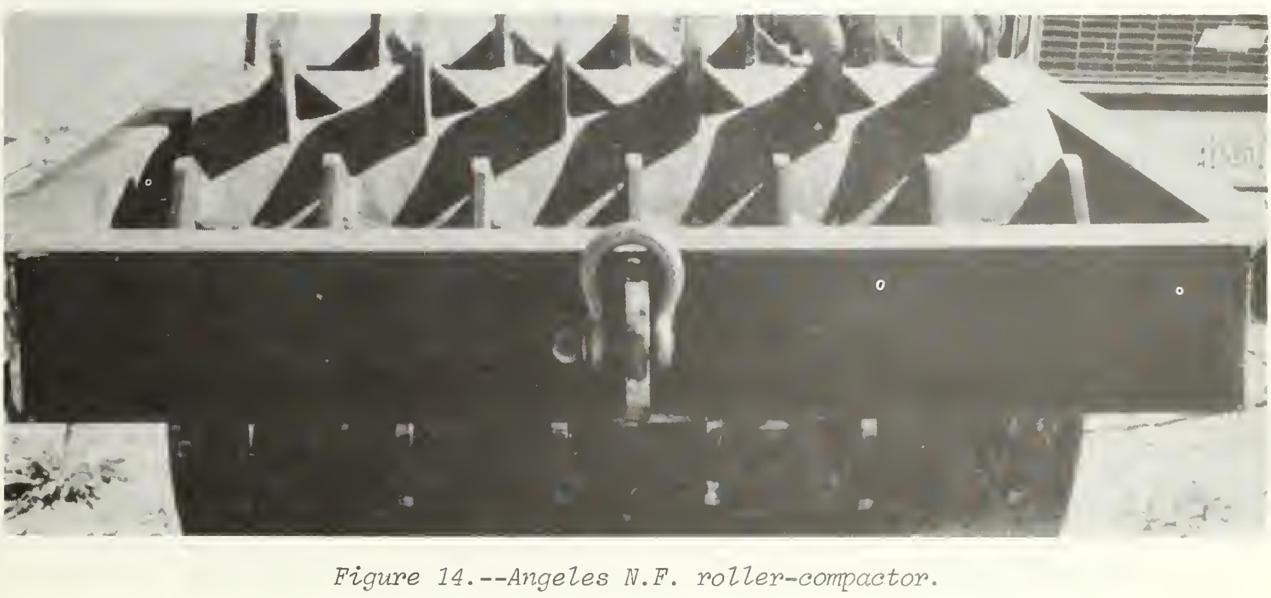

Figure 14.--Angeles N.F. roller-compactor.

Esthetics

As emphasized in this report, esthetics are probably influenced by the width of the road cross-section and clearing more than anything else. (Also, visual impact of the effects of raw cut-and-fill slopes, whatever the road width, is reduced by revegetation.)

A view of the basin (showing the old road) before clearing for the new road is shown in figure 15; a view after clearing for the new road is shown in figure 16. (Figures 12 and 13 show two sections of the new road, particularly effects of reduced clearing width.)

In figure 15, the clearing and cross section of the old road are prominent in the center of the picture. In figure 16, the same view after the new road was completed, the clearing for the new road is barely visible above the old road. Figure 12 shows a cut-and-fill section using conventional backslopes and clearing specifications. Compare this photo with figure 13 where 1/10:1 backslopes and reduced clearing widths were used. (Both photos were taken before final cleanup and grading.)

To minimize miles of road, one must use logging systems that require few roads. The research on the Coram site was to demonstrate the effects of logging systems that require fewer miles of road and produce less impact than conventional methods. Instead of the traditional Idaho jammer that required road spacings of 300-600 feet, (91-182 m) a skyline system was selected that had the potential to increase road spacing to about 2,000 feet (610 m). In steep country (>50 percent slopes), if road spacings are decreased, it generally means the road will require switchbacks to gain elevation. This was the case for the experimental portion of Abbot Basin road 590-B, as seen in figure 2 and appendix figures 18 and 19.

Figure 15.--Abbot Basin before construction of logging study road.

Figure 16.--Abbot Basin after construction of logging study road.

DISCUSSION AND CONCLUSIONS

In the future, an important consideration for construction of forest roads will be to reduce the environmental and social impact while still providing access needed for resource utilization.

For the experimental road on the Coram research site, a decision was made to reduce elements of design to the near minimum needed for operation of the logging equipment and evaluate the results. The road is located on an experimental forest and is a system road, but subject to atypical volumes of traffic because it is dedicated to research experimentation. Therefore, the road was evaluated for both the traffic associated with experimental logging and traffic assumed for a typical system road.

For the experimental sale, the single-lane road clearly was the best choice, environmentally. For a system road carrying normal traffic, including timber volumes of up to 4- to 5-million bd. ft. (15,840-19,800 m^3) annually, the reduced environmental impacts of a well-designed and well-constructed single-lane road may still be available at some acceptable level of economic sacrifice. For heavier volumes of traffic, especially logging traffic, then the trade-offs become more significant and require more difficult decisions about standards.

Estimated hauling cost differences for a wider single-lane road and a double-lane road for two assumed traffic volumes (10 VPH and 5 VPH) showed the 5 VPH traffic near the break even point for single-lane vs double-lane roads related to hauling cost for this sale.

Although final reports are not yet available from the results of esthetic and hydrologic impacts and revegetation experiments, some general observations are possible. Esthetic impacts of a single-lane road with reduced clearing widths definitely appear to have been an improvement over standard practices.

Although the hydrology has been changed, as it always is when logging and road construction are imposed on the land, there is no evidence to date of adverse impacts from sediment or changes in runoff and streamflow.

Early results from the revegetation experiments show good success from the shrub planting and the impregnated mulch treatment. The plantings and seeding experiments will be effective in reducing visual and environmental impacts.

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1971. Forest road standards as related to economics and the environment. USDA For. Serv. Res. Note INT-145, 44 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

APPENDIX A

Alinement Experimental Section Abbot Basin Road 590-B

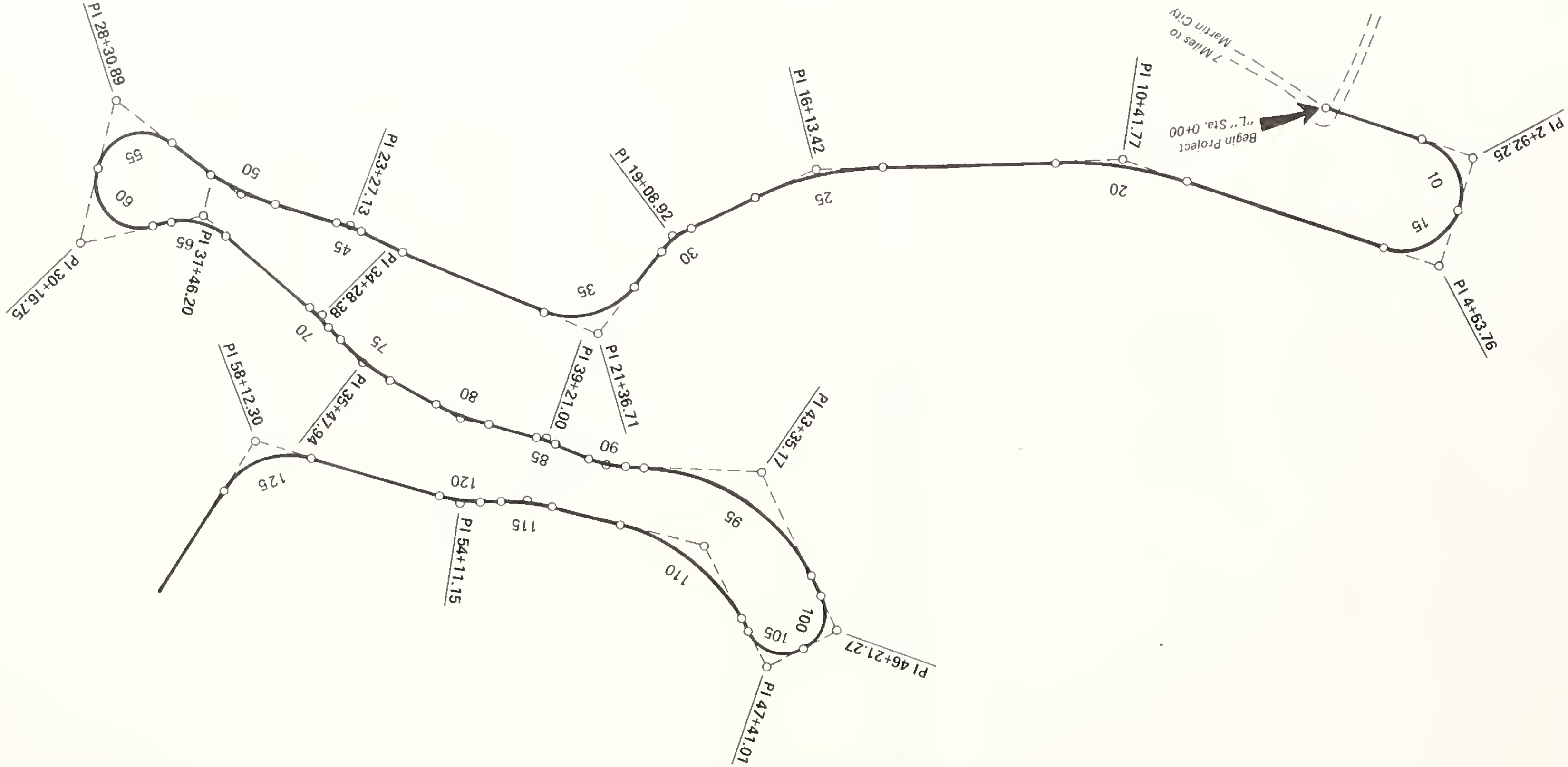


Figure 17.--Alinement--experimental section Abbot Basin road 590-B, stn. 0+00 to P1 58+12.30.

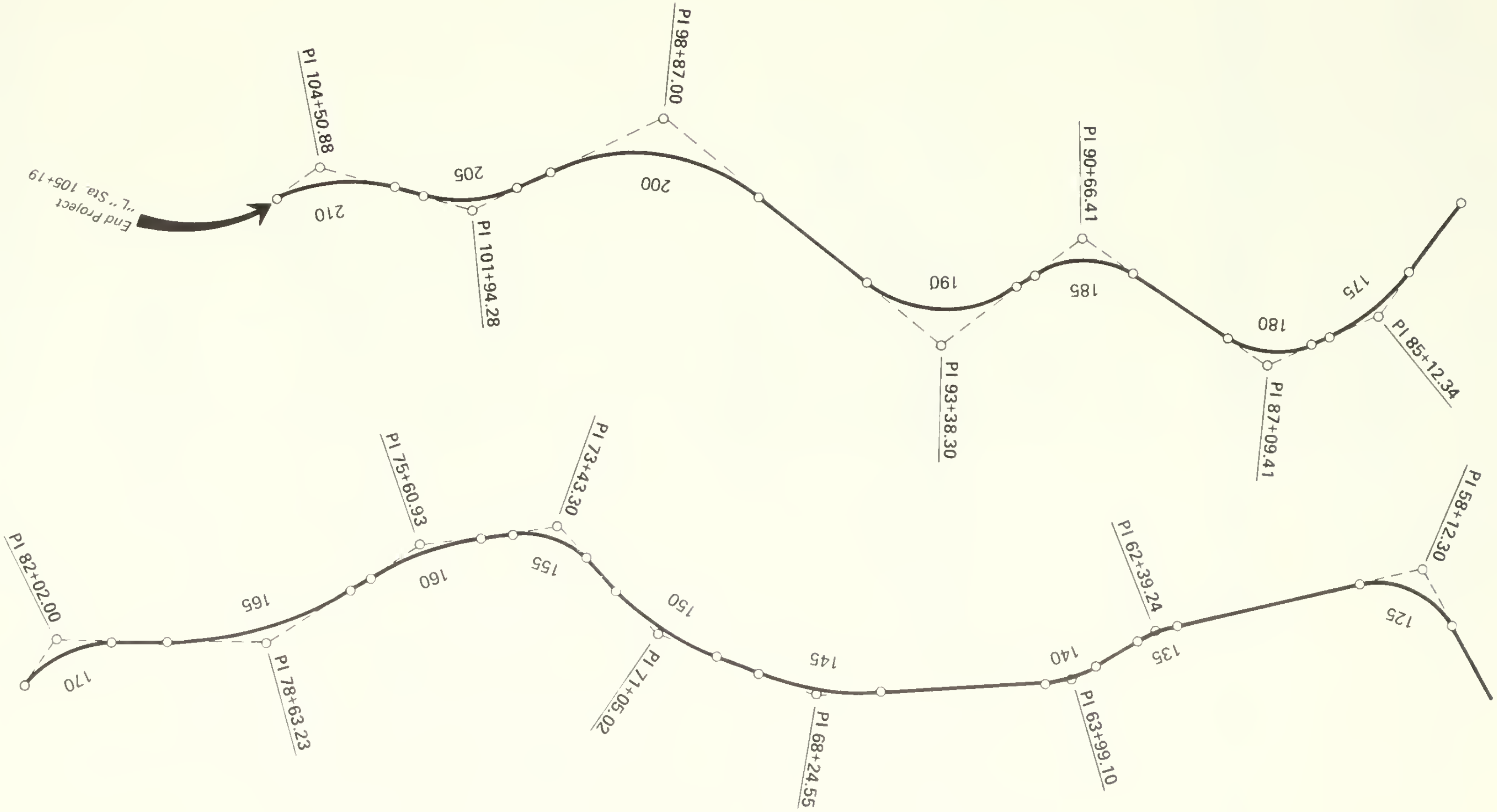
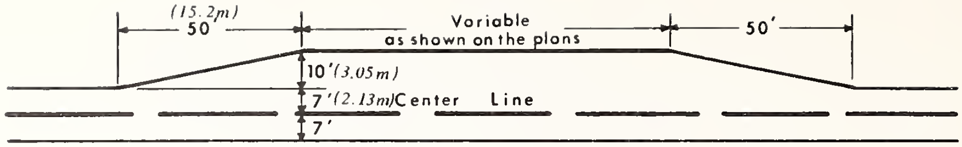


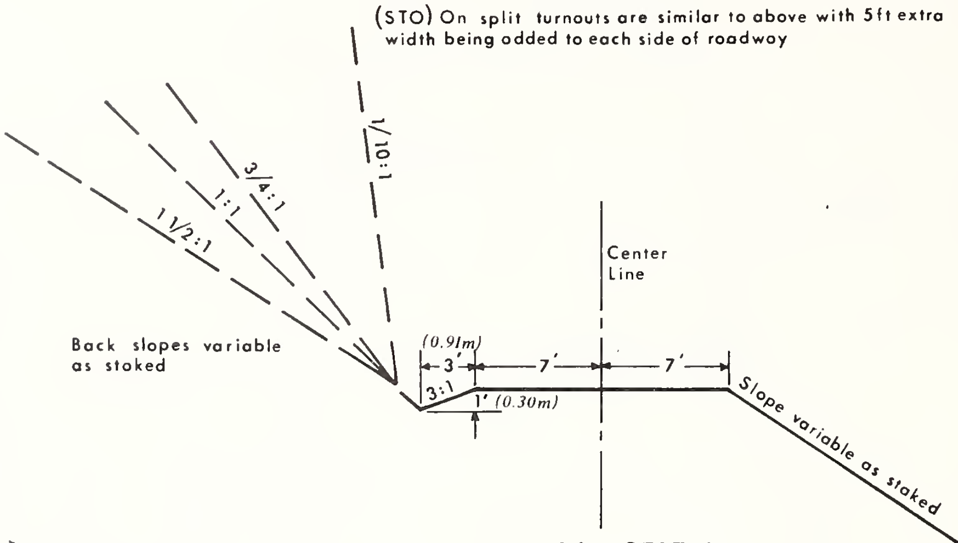
Figure 18.--Alinement--experimental section Abbot Basin road 590-B, 58+12.30 to stn. 105+19.



TYPICAL TURNOUT SECTION

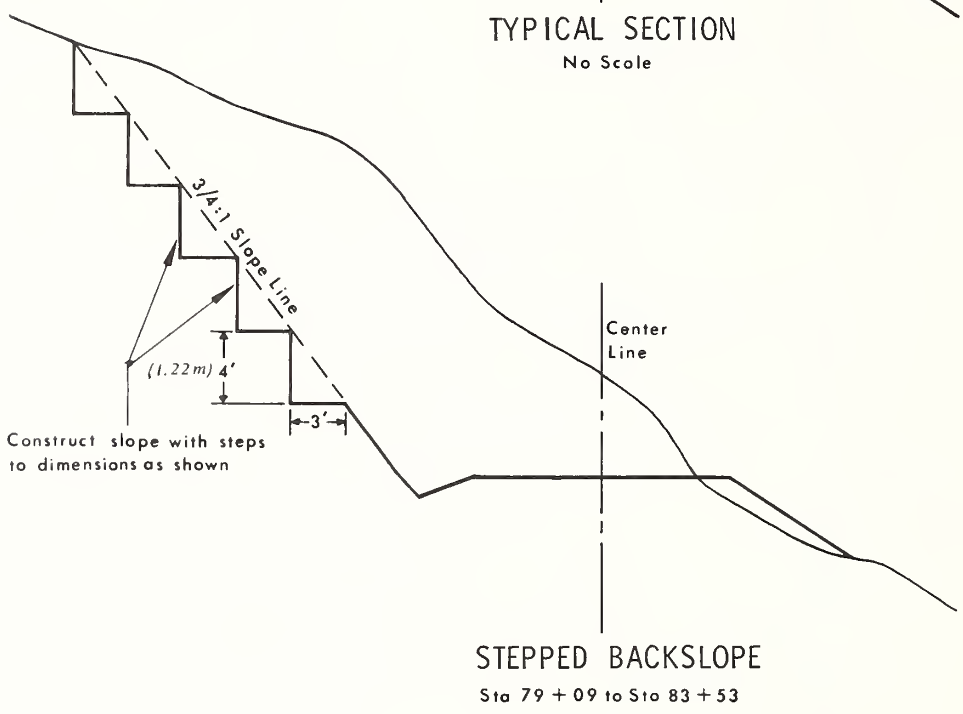
No Scale

(STO) On split turnouts are similar to above with 5ft extra width being added to each side of roadway



TYPICAL SECTION

No Scale



STEPPED BACKSLOPE

Sta 79 + 09 to Sta 83 + 53

No Scale

Figure 19.--Typical sections for turnouts, cut-and-fill slopes, and stepped backslopes.

APPENDIX B

Revegetation of Road Slopes . . . Shrubs and Grasses Planted

Table 8.--*Shrub survival data--spring planting 1974* [illegible]

Species	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Total	
	No. planted	%	No. planted	%	No. planted	%	No. planted	%	No. planted	%	No. planted	%	No. planted	%
Woods rose (*Rosa woodsii*)	249	98	96	92	89	99	80	94	41	95	86	94	641	96
Redosier dogwood (*Cornus stolonifera*)	33	100	14	94	--	--	46	100	--	--	--	--	93	99
Chokecherry (*Prunus virginiana*)	316	87	62	92	134	72	91	86	59	95	106	85	768	85
Serviceberry (*Amelanchier florida*)	404	84	75	76	129	87	103	93	66	82	151	89	928	85
Blackcap (*Rubus occidentalis*)	39	85	23	87	--	--	--	--	--	--	--	--	62	85
Spirea (*Spirea lucida*)	188	72	66	66	138	41	73	92	--	--	--	--	461	65
Blue elderberry (*Sambucus glauca*)	27	96	--	--	--	--	--	--	--	--	--	--	27	96
Black elderberry (*Sambucus canadensis*)	49	59	23	30	--	--	--	--	--	--	--	--	72	50
Redstem ceanothus (*Ceanothus sanguineus*)	303	66	56	41	106	13	95	67	63	27	113	73	736	54
Ninebark (*Physocarpus malvaceus*)	68	75	25	72	--	--	--	--	--	--	--	--	93	74
Beard tongue (*Penstemon* uk.)	170	65	48	46	97	26	--	--	66	64	88	51	469	52
Thimbleberry (*Rubus odoratus*)	35	80	24	79	--	--	--	--	--	--	--	--	59	80
Sumac (*Rhus glabra*)	27	44	19	47	--	--	--	--	--	--	--	--	46	46
Mountain mahogany (*Cercocarpus*)	--	--	29	45	--	--	--	--	--	--	--	--	29	45
Evergreen ceanothus (*Ceanothus* uk.)	322	21	93	28	120	16	89	28	57	33	81	33	762	24
Oceanspray (*Holodiscus discolor*)	26	4	24	13	--	--	--	--	--	--	--	--	50	8
Lupine (*Lupinus*)	236	2	105	3	--	--	84	6	52	0	95	0	572	2

Table 9.--*Grass and legume mixture used to seed slopes of experimental road.*

Species	Rate/acre	Kg/hectare
	Pounds	*(Kg)*
Alta tall fescue	2.5	(2.81)
Manchar smooth brome	4.0	(4.49)
Orchardgrass	2.5	(2.79)
White Dutch clover	2.0	(2.25)
Birdsfoot trefoil	2.0	(2.25)

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field programs and research work units are maintained in:

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- Boise, Idaho
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- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)
- Reno, Nevada (in cooperation with the University of Nevada)

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Gardner, Rulon B.
1978. Cost, performance, and esthetic impacts of an experimental forest road in Montana. USDA For. Serv. Res. Pap. INT-203, 28 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

An experimental logging road designed to minimize environmental and esthetic impact was constructed in northwest Montana. The road was single-lane (14-foot finished surface, 3-foot ditch), constructed along the contour. Esthetically, the single-lane experimental road was judged far superior to existing roads on the forest.

KEYWORDS: forest roads, logging roads, road design, environmental impact

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